A Burner

The present invention relates to a burner for generating a hot gas, and in particular to a pre-mix burner connectable to a combustion chamber.

Many gas burners rely on swirling to produce efficient mixing of reactants. However, interaction between the complex flow patterns within the swirling fluid and acoustic resonant modes in the combustion chamber can lead to undesired thermoacoustic pulsations or vibrations. These pulsations are associated with coherent vortical flows in the combustion chamber. The vortical flows introduce periodicity into the mixing process, which may lead to periodic heat release and resonant coupling with the combustor acoustic resonant modes. Vortical mixing of the reactants also tends to be limited to large scale mixing with the result that mixing in regions between vortices in the vortical flow tends to be poor.

Thermoacoustic vibrations are problematic in combustion processes, since they can lead to high-amplitude pressure fluctuations, as well as to a limitation in the operating range of the burner in question and to increased emissions from the burner. Many combustion chambers do not possess adequate acoustic damping to account for such thermoacoustic vibrations.

In conventional combustion chambers, the cooling air flowing into the combustion chamber acts to dampen noise and therefore contributes to the damping of thermoacoustic vibrations. However, in modern gas turbines, an increasing proportion of the cooling air is passed through the burner itself in order to achieve low emissions. The cooling air flow within the combustion chamber is thus reduced, resulting in reduced damping of the thermoacoustic vibrations in the chamber.

Another method of damping is the coupling of Helmholtz dampers in the combustion chamber, preferably in the region of the combustion chamber dome or in the region of

the cold air supply. However, such dampers require a considerable amount of space in order to allow them to be accommodated in the combustion chamber. Since modern combustion chambers tend to be relatively compact, it is usually impossible to incorporate Helmholtz dampers in the combustion chamber without substantial re-design of the chamber.

A further method of controlling thermoacoustic vibrations involves active acoustic excitation. In this process, a shear layer which forms in the outlet region of the burner is acoustically excited. A suitable phase lag between the thermoacoustic vibrations and the excitation vibrations makes it possible to achieve damping of the combustion chamber due to the superimposition of the vibrations and the excitation. However, a considerable amount of energy is expended in generating such acoustic excitation.

A further means of providing damping in the combustion chamber is to modulate the fuel mass flow in the burner. Fuel is injected into the burner with a phase shift relative to measured signals in the combustion chamber so that additional heat is released at a minimum pressure . This reduces the amplitude of the thermoacoustic vibrations. However, this technique also leads to high emissions due to the increased fuel.

A further alternative is to inject air into the burner via nozzles to disturb and break up the vortical flow. However, the required additional pipes and plumbing complicates the design of the combustor. Furthermore, the required additional air flow reduces the overall efficiency.

In a similar technique, the vortical flow is broken up by baffles which are located inside the burner in order to disturb the vortical flow. However, the inclusion of such baffles increases the constructional outlay of the burner, which is disadvantageous.

An object of the present invention is to provide a burner in which the above disadvantages are overcome.

The invention provides a burner for a heat generator comprising an outlet connectable to a combustion chamber, wherein at least part of the inner surface of the outlet is provided

with corrugations which are adapted to facilitate the production of axial vorticity in the region of the outlet.

In a preferred embodiment of the invention, the corrugations are provided over substantially all of the inner surface of the outlet. The corrugations are preferably in the form of lobes. Alternatively, the corrugations are rectangular or triangular in cross-section.

The invention will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an outlet of a burner according to the invention;

Figure 2 is a cross-sectional view of the burner of Figure 1 along the line A-A;

Figure 3 is a diagram of the flow in the region of an outlet of the burner of Figures 1 and 2;

Figure 4 is a graph showing the effect of the invention on pressure fluctuations, and

Figure 5 is a graph showing the effect of the invention on emissions.

In Figure 1, a heat generator has a burner 1 with a swirl generator 2. The swirl generator 2 generates a swirl 3 with an axial flow component facing toward a downstream burner outlet 4. Mixing takes place in an area 5 of the generator 2, so as to ensure adequate mixing of fuel and combustion air. The axial flow cross-section of the area 5 widens in the direction of the outlet 4; this configuration facilitates attainment of a constant swirl 3 in the area 5 with an increasing combustion air mass flow in the direction of the longitudinal axis B of the burner 1. The generator 2 comprises two hollow partial cones (not shown) arranged offset to one another. The offset of the respective centre axes of the partial conical bodies creates two tangential air channels 6. A combustion air flow 7 flows, with a relatively high tangential velocity component,

through the two tangential channels 6 into the area 5, thus generating the swirl 3. Fuel is introduced into the burner 1 via a fuel inlet 8 in the form of a nozzle.

The burner 1 is attached to a combustion chamber 9 via an outlet 10 through which the swirl 3 passes. The swirl 3 contains vortical flow, which causes flow instabilities including thermoacoustic vibrations which result in low performance of the combustion chamber.

An inner surface of the outlet 10 is provided with corrugations 11 in the form of lobes. The preferred range of the ratio of the length to the depth of the lobes is 1:1 – 3:1, but can be as high as 10:1. The corrugations 11 can cover the entire mixing section of the burner, or as little as 20% of the length of the mixing section. As the swirl 3 passes through the outlet 10, it passes through elongations 12 between the lobes 11. Opposing radial velocity components arise in the swirl 3 as a result of the lobes 11 and cause radial shear, which produces a relatively intense axial vorticity. The axial vorticity is superimposed on the vortical flow in the swirl 3 in order to break up the vortical flow, thus decreasing the coherence of the vortical flow and increasing turbulence in the region of the outlet 10. This results in increased flow stability. In addition, the axial vorticity provides enhanced small scale mixing in the region of the outlet 10. The flow in the region of the outlet 10 is shown in Figure 3.

Figure 4 shows the effect of the burner according to the invention on pressure fluctuations according to variation in Lambda number. Line 13 is effectively a baseline, i.e. it represents a burner which has not been modified in any way. Line 14 represents a burner having a corrugated nozzle with a post (not shown), i.e. an extension of the fuel inlet 8 along approximately 2/3 of the length of the swirl generator 2, and fuel injection. Line 15 represents a burner having a corrugated nozzle with a post in the head region of the outlet 7 without fuel injection. Line 16 represents a corrugated nozzle without a post.

Figure 5 shows the effect of the burner according to the invention on emissions according to variation in Lambda number. Line 13a is effectively a baseline, i.e. it represents a burner which has not been modified in any way. Line 14a represents a

burner having a corrugated nozzle with a post (not shown) and fuel injection. Line 15a represents a burner having a corrugated nozzle with a post without fuel injection. Line 16a represents a corrugated nozzle without a post.

It will be appreciated that variations of the embodiment described above are possible. Alternative configurations of pre-mix burners are well-known to persons skilled in the art. Similarly, it would be possible to replace the conical swirl generator 2 with a cylindrical swirl generator. It is also known to arrange a displacement body, tapering towards the outlet 10, inside the swirl generator; this could provide a further alternative embodiment of the invention.

Although the corrugations 8 are in the form of lobes, they could also be of rectangular, square, triangular or trapezoidal cross-section. The lobes can be tapered and rounded at the edge, straight and rounded at the edge, half-circular, half-elliptic, half-oval, or stepped. They can also be tapered along their ridges or straight.